RESEARCH NOTES
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Non-Destructive Measurement of Pavement Layer Thickness

RESEARCH SUMMARY: ***Several non-destructive methods to measure average thickness of Asphalt Concrete (AC) and Portland Cement Concrete (PCC) pavements were evaluated. Two ground penetrating radar (GPR) methods were shown to be capable of measuring new pavement average thickness in AC pavements to within 2.5 mm (0.1 inch). Impact-echo (IE) methods were tested on PCC pavements but were only accurate to 5.0 mm (0.2 inch).***

Why this research is important

Pavement thickness is an important factor in determining the quality of new pavements and overlays. Pavement that is too thin will not last as long, so accurate and efficient pavement thickness testing has important economic implications. According to the models, for example, a difference of only 13 mm (0.5 inch) on a 91 mm (3.6 inch) thick pavement can lead to a 40% reduction in pavement life, significantly impacting the cost of maintaining our roads.

Currently in California, pavement thickness is determined by extracting core samples, typically 3 samples per 305 m (1000 feet). This method is very accurate, but it damages the pavement, is time-consuming, and does not produce enough measurement points to generate a fair representation of the overall pavement thickness. A quicker, non-destructive pavement thickness measurement method is needed.

Studies have shown that to accurately establish the contractor pay factors, the mean value of pavement thickness has to be determined to within 2.5 mm (0.1 inch). It is also important to take enough sample points to accurately determine the mean pavement thickness throughout the project. For example, if the thickness of a pavement has a standard deviation of 5 mm (0.2 inch), we would need to drill 70 cores to meet the 2.5 mm (0.1 inch) accuracy requirement. A non-destructive method, even if less accurate than core measurements, could accomplish this by providing many more data samples.

Research Results

Asphalt and Portland Cement Concretes (AC and PCC) have different properties when they are new, and require different testing methods. *Electromagnetic methods* have been used successfully to measure thickness in AC pavements. Because PCC pavements contain free water after construction that attenuates the electromagnetic energy, *mechanical wave methods* provide the best way to measure thickness.

AC Pavements

Ground Penetrating Radar (GPR) techniques radiate electromagnetic pulses with an antenna and pick up the signal reflected from the pavement layers. Analysis of these reflected signals provides information on the thickness of the pavement and its electromagnetic properties.

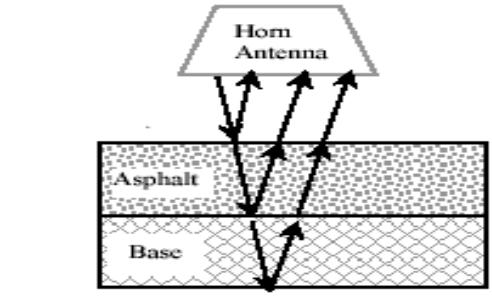

Figure 1: The non-contact horn GPR

Two basic types of GPR systems were used for the asphalt pavement evaluation: the *non-contact horn antenna* systems and the *contact ground-coupled* systems. The horn antenna (see Figure 1) can be used to determine both the thickness of the asphalt layer and its electromagnetic properties.

The ground-coupled systems place the antenna directly in contact with the pavement (see Figure 2). This has the advantage of transmitting more power into the ground, but a set of calibration curves is normally needed to determine the electromagnetic properties and calculate the pavement thickness. A variation of this system is the *common mid-point method* (CMP), which moves the transmitter and receiver at equal distances from a common midpoint. This enables a direct calculation of material properties and thickness.

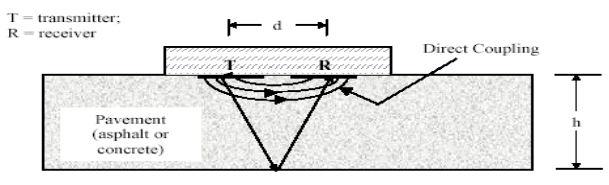

Figure 2: The ground coupled GPR

Both systems worked well on AC pavements, although the CMP method showed more variability. The results of the horn antenna vs. core data for California field tests are shown in Figure 3. The results of the CMP methods are shown in Figure 4. Note that both methods require a core for calibration. Both methods were able to meet the 2.5 mm (0.1 inch) accuracy requirement.

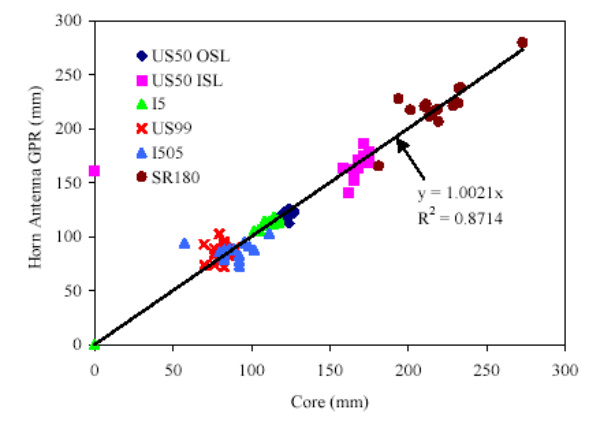

Figure 3: Horn Antenna vs. Core Data after Calibration

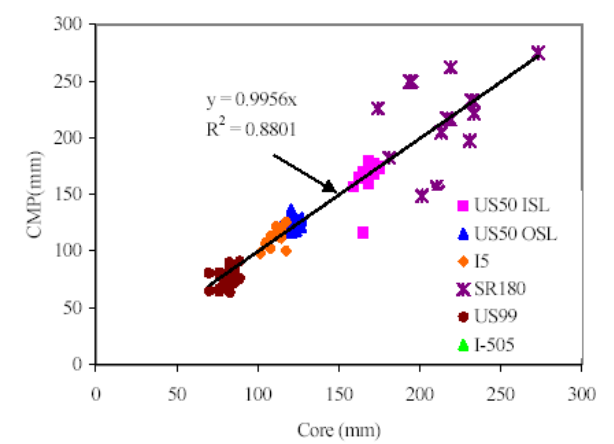

Figure 4: CMP vs. Core Data after Calibration

PCC Pavements

Several mechanical wave methods were evaluated to measure the thickness of PCC pavements. The best results were obtained with the *Impact-echo* (IE) method. IE methods work by hitting the pavement with a metal ball or hammer and listening for the echoes (see Figure 5). The multiple echoes create a resonance, which can be related to the thickness once the wave velocity in the concrete is known. The most reliable method to determine velocity is to use calibration cores.

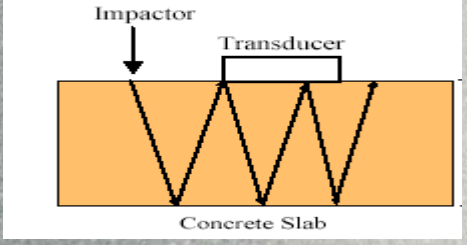

Figure 5: IE method for PCC pavements

The IE methods for PCC pavements showed more measurement error than the GPR methods for AC pavements (see Figure 6). They were not able to meet the initial accuracy goals, but they can be useful for providing good estimates of PCC thickness.

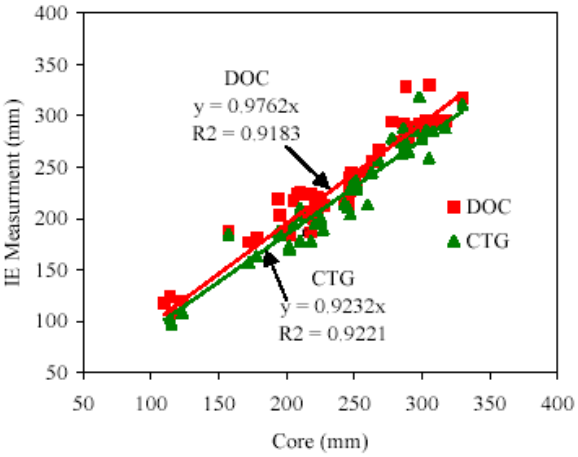

Figure 6: IE method for PCC pavements.

Recommendations

The results of this research show that both GPR methods can be used to perform quality assurance measurements of AC pavements. Specifications of the equipment used in this method are provided in the report. Inspectors would need training on this measurement method.

Although the IE methods don't meet the accuracy specifications, it may be worthwhile to continue evaluating these units in the field.

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